Catch, Origin, Distribution and Growth of Pacific Salmon in Hecate Strait

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ABSTRACT

Withler, F. C., and F. Y. C. Wong. 1982. Catch, origin, distribution and growth of Pacific salmon in Hecate Strait. Can. Tech. Rep. Fish. Aquat. Sci. 1173: iv + 38 p.

Fishing areas adjacent to and including Hecate Strait contribute significant proportions of B.C.'s total salmon landings, but the main salmon fishery on the open waters of the Strait itself is trolling for chinooks and coho. Recoveries of chinooks tagged in the Strait have ranged from S.E. Alaska to the Columbia River. Tagged coho were recovered from S.E. Alaska to southern B.C., although the majority were recovered in northern and central B.C. Tagged even-year pinks were recovered from northern B.C. and from the Strait of Georgia and Puget Sound. Tagged sockeye were recovered in northern and central B.C. coastal areas.

Juveniles of all 5 species are present in the open waters of Hecate Strait from at least mid-July until October, and in the case of chums, pinks and sockeye, until November. During this period they are feeding and growing. Their abundance and origins are unknown.

Major perturbations in the Strait, as might arise from oil drilling and extraction, would likely affect juveniles more seriously than maturing salmon. To assess the distribution and abundance of juveniles (and hence the vulnerability of salmon stocks present) it will be necesary to sample and tag juveniles systematically over the whole Strait.

Key words: Hecate Strait, chinooks, coho, sockeye, pinks, chums, juveniles, maturing adults, catches, distribution, growth, feeding, stock origins, tagging, juvenile surveys.

RESUME

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Une grande partie des débarquements totaux de saumons en Colombie-Britannique proviennent des pêcheries du détroit d'Hécate et des zones adjacentes. Dans les eaux libres du détroit, on pêche principalement les saumons quinnats et cohos aux lignes traînantes. Des quinnats et des cohos étiquetés et relâchés dans le détroit ont été recapturés au sud-est de l'Alaska jusqu'au fleuve Columbia et du sud-est de l'Alaska jusqu'au sud de la Colombie-Britannique respectivement. Toutefois, la majorité des cohos ont été repris dans le nord et le centre de la C.-B. Des saumons roses étiquetés les années paires ont été repris dans le nord de la C.-B. et dans les détroits de Géorgie et de Puget. Des saumons sockeyes étiquetés ont été repêchés dans les zones côtières septentrionales et centrales de la C.-B.

Des juvéniles des cinq espèces étaient présents dans les eaux libres du détroit d'Hécate à partir au moins de la mi-juillet jusqu'à october, et jusqu'à novembre, dans le cas des sockeyes, roses et kétas. Pendant cette période, ils se nourrissent et croissent, mais on ne connaît pas leur abondance ni leur origine.

Des perturbations importantes dans le détroit, que pourraient causer par exemple le forage ou l'extraction de pétrole, influeraient probablement plus sur les juvénile que sur les saumons en maturation. Il sera nécessaire d'échantillonner er d'étiqueter systématiquement les juvéniles dans tout le détroit afin d'évaluer leur répartition et leur abondance (et ainsi connaître la vulnérabilité des stocks de saumons présents).

Mots-clés: détroit d'Hécate, quinnats, cohos, sockeyes, roses, kétas, juvéniles, adultes en maturation, prises, répartition, croissance, alimentation, origine des stocks, étiquetage, levés sur les juvéniles

INTRODUCTION

In response to the need to coordinate the activities of the Fisheries Research Branch and the Institute of Ocean Sciences of the Canada Department of Fisheries and Oceans in northern British Columbia waters, the Director of the Fisheries Research Branch in 1981 established the "Hecate Strait Committee". One of the terms of reference of the Committee was to "evaluate quality and completeness of past research on fisheries resources in Hecate Strait, and to identify knowledge gaps and areas of high sensitivity to perturbation and/or species survival". This report brings together the information about Pacific salmon in Hecate Strait with respect to the above term of reference and comments briefly on "knowledge gaps and areas of high sensitivity...".

The purpose of the report is to make the information and references to source material more readily available to those who might need them. The reader should note that our area of greatest interest is the open water of Hecate Strait, but that the presence of salmon in the Strait can only be put in perspective if their relationship to shoreward fishing and rearing areas is considered. Hence we sometimes refer to the "study area" which includes Fishery Statistical Areas 2E, 4, 5 and 6, parts of which include all the area considered to be Hecate Strait (Fig. 1).

CATCH AND ESCAPEMENT

Salmon in Hecate Strait and adjacent areas have been exploited commercially since the turn of the century. However reliable catch and escapement data became available only beginning in 1951. Catches in the study area of all species from 1951 to 1979 ranged from 1.8 million to 10.8 million pieces, with pink and sockeye being most abundant (Table 1). Landings from this area comprise 12 to 38 percent (average 21%) of the B.C. total. Table 2 shows, on average, that more than 35% of the even-year pinks, 20% of the odd-year pinks, 20% of the chums, 17% of the sockeye, 13% of the coho and 11% of the chinooks landed in B.C. came from this area. However the number of chinooks and coho caught in Hecate Strait itself (mostly by troll gear) amounts to less than 5% of the total B.C. landings of these species combined. Landings of pink, chum and sockeye in Hecate Strait are negligible because these species are caught almost exclusively by net fisheries conducted in more sheltered waters adjacent to the open Strait.

Escapement to the 260 or so spawning streams around Hecate Strait ranged from 1.2 million to 6.5 million (Table 3). Except for coho and chinooks, the relative abundances of fish caught in a statistical area more or less reflect the relative production from that area. This fact is demonstrated in the following sections which describe in more detail the catch and escapement of each species in the four statistical areas concerned.

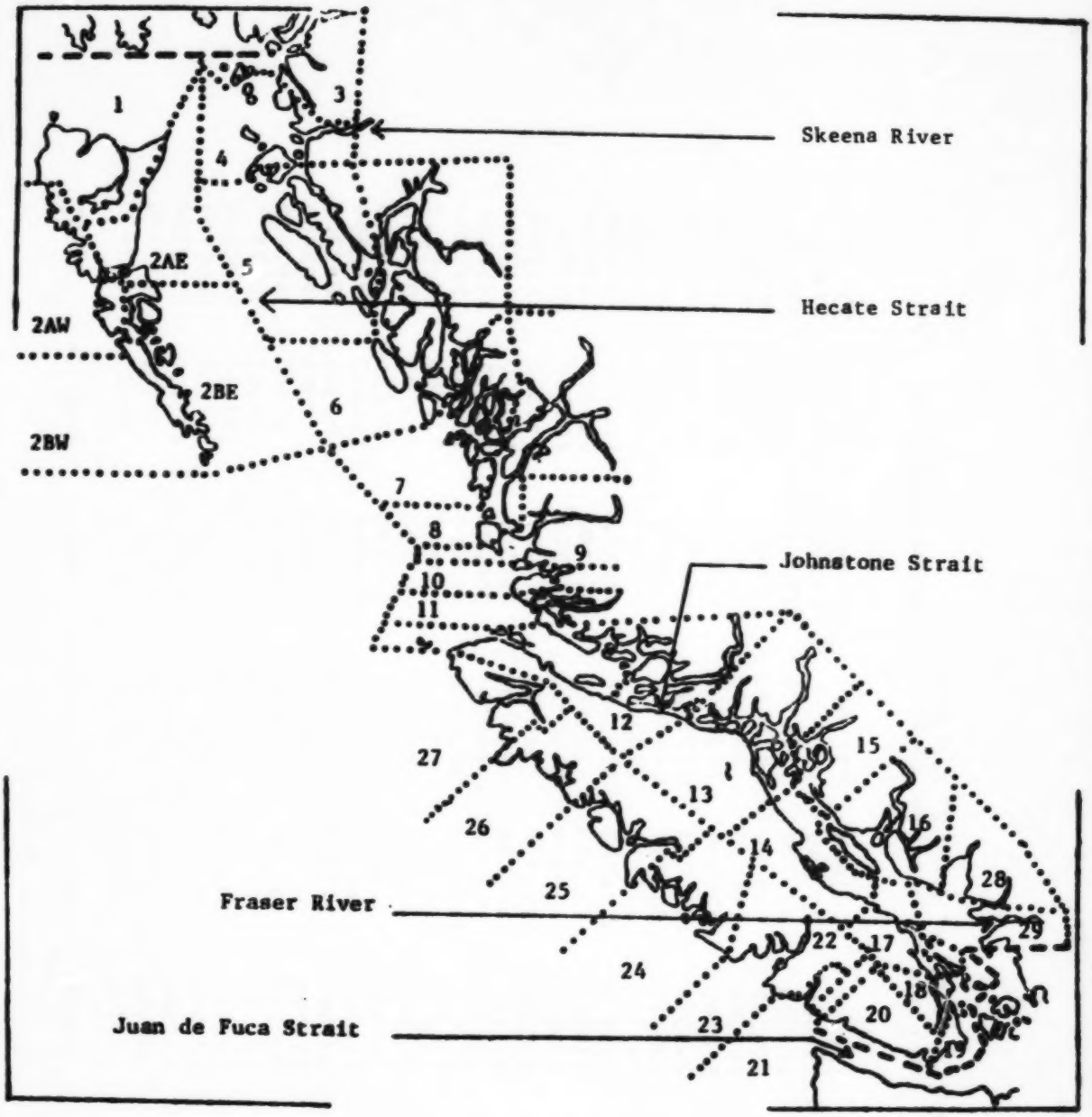

Fig. 1. B.C. Fishery Statistical Areas. Area 2AE + Area 2BE = Area 2E.

YEAR	COHO	SOCKEYE	PINK	CHUM	CHINOOK	TOTAL
51	565100	839100	1924700	917000	87700	4333600
52	437400	1445100	4651700	219700	123200	6877100
53	221700	827500	688300	379100	102100	2218700
54	351800	743700	1890900	842500	71700	3900600
55	345600	287000	2619200	147000	61900	3460700
56	459100	263300	2875700	239500	58500	3896100
57	362100	337800	2773300	380800	51600	3905600
58	314000	801700	2886000	426900	76800	4505400
59	261900	313800	1122600	70900	75300	1844500
60	291300	294400	1609600	185200	84500	2465000
61	351800	1059800	3061500	243600	59500	4776200
62	587300	688900	7783200	402100	102100	9563600
63	684100	303300	2814000	391200	114200	4306800
64	866600	1049100	4276100	945600	143400	7280800
65	727500	508400	1801500	300500	141400	3479300
66	1021600	788200	7666000	555200	144800	10175800
67	322200	1165600	590600	515700	140900	2735000
68	939600	928300	5728600	1021700	158100	8776300
69	233800	620300	586400	150400	139800	1730700
70	507300	769900	6137200	755100	129700	8299200
71	362100	950900	1352900	441200	152000	3259100
72	758900	853100	7985600	990200	227800	10815600
73	372000	1407000	1182000	709000	157000	3827000
74	328600	1458700	1251900	394800	165200	3599200
75	166000	540000	921000	54000	150000	1831000
76	372000	688000	2859000	89000	136000	4144000
77	191000	922000	2149000	325000	92000	3679000
78	374000	501000	3730000	443000	93000	5141000
79	256000	1340000	1517000	160000	100000	3373000

Table 1. Total numbers of salmon, by species, caught annually in Fishery Statistical Areas 2E, 4, 5 and 6, 1951-1979.

YEAR	COHO	SOCKEYE	PINK	CHUM	CHINOOK	TOTAL
51	0.14	0.19	0.16	0.16	0.11	0.16
52	0.16	0.30	0.41	0.09	0.14	0.31
53	0.08	0.14	0.06	0.08	0.10	0.09
54	0.14	0.11	0.35	0.14	0.08	0.18
55	0.12	0.10	0.23	0.09	0.07	0.18
56	0.16	0.08	0.39	0.10	0.06	0.23
57	0.12	0.11	0.25	0.16	0.06	0.19
58	0.11	0.07	0.42	0.13	0.07	0.17
59	0.09	0.10	0.17	0.03	0.08	0.12
60	0.14	0.10	0.39	0.10	0.11	0.21
61	0.11	0.23	0.37	0.20	0.09	0.26
62	0.16	0.20	0.33	0.27	0.14	0.29
63	0.20	0.15	0.23	0.27	0.14	0.22
64	0.21	0.29	0.44	0.42	0.15	0.35
65	0.16	0.17	0.35	0.47	0.14	0.25
66	0.19	0.20	0.44	0.42	0.12	0.35
67	0.10	0.17	0.06	0.46	0.13	0.13
68	0.18	0.15	0.29	0.33	0.15	0.25
69	0.10	0.15	0.23	0.11	0.13	0.15
70	0.15	0.19	0.45	0.21	0.11	0.32
71	0.08	0.15	0.16	0.35	0.10	0.15
72	0.24	0.24	0.56	0.16	0.15	0.38
73	0.11	0.19	0.18	0.11	0.11	0.15
74	0.09	0.20	0.17	0.18	0.12	0.17
75	0.07	0.24	0.20	0.05	0.11	0.16
76	0.11	0.14	0.28	0.05	0.09	0.19
77	0.06	0.15	0.21	0.30	0.06	0.16
78	0.11	0.07	0.36	0.15	0.07	0.20
79	0.07	0.24	0.13	0.19	0.08	0.14
AVERAGE	0.13	0.17	0.29	0.20	0.11	0.21

Table 2. Proportions by species, by year, of the total B.C. catches of salmon taken in Fishery Statistical Areas 2E, 4, 5 and 6, 1951-1979.

YEAR	COHO	SOCKEYE	PINK	CHUM	CHINOOK	TOTAL
51	348808	372529	1162831	883575	26405	2794148
52	233279	556839	2798975	721475	24875	4335443
53	193010	849018	461650	387175	47825	1938678
54	272385	718676	946520	527570	55325	2520476
55	292885	174922	598250	146250	61525	1273832
56	477190	478201	1130781	209100	52200	2347472
57	271820	629490	1209725	337600	59675	2508310
58	275960	940513	1392775	430145	66600	3105993
59	174475	942767	1940734	75043	98950	3231969
60	197129	381615	1357228	359668	36652	2332292
61	307402	1093677	2541075	282687	28400	4253241
62	235172	759853	4817300	656125	50800	6519250
63	302034	931830	2677975	500033	65600	4477472
64	375934	996507	3496095	747430	45975	5661941
65	342305	750010	1967660	384580	40490	3485045
66	403205	580359	2741694	775657	57983	4558898
67	216511	748533	781082	634650	50415	2431191
68	300240	722193	3819808	720434	42925	5605600
69	202610	743829	1101315	267972	41262	2356988
70	236650	748125	2649335	320040	34825	3988975
71	172249	922375	1600642	453232	42175	3190673
72	182736	731626	3738512	506050	33405	5192329
73	139245	914383	1545290	536626	53220	3188764
74	114130	810946	1466701	425822	43376	2860975
75	146340	918872	2351845	172263	26254	3615574
76	146220	782897	2597513	234080	21308	3782018
77	133980	1002795	1222069	289953	34918	2683715
78	114997	461250	1842963	206453	30764	2656427
79	88700	1163240	1033435	105460	26422	2417257

Table 3. Total numbers of each species recorded as escapement in Fishery Statistical Areas 2E, 4, 5 and 6, 1951-1979.

(i) Chinooks. Catches were fairly stable at around 70,000 pieces per year until the early 1960s (Table 1). Beginning in 1962, landings increased steadily to a peak of 230,000 pieces in 1979. Trolling along shorelines and more open waters in Hecate Strait accounts for more than 70% of the total landings. Net catches are mostly incidental to fisheries aimed at other salmon species in more sheltered waters of Areas 4, 5 and 6. Increasing catches in Area 2E since 1969 and decreasing catches in Area 5 since 1972 are due to changes in trolling effort rather than to changes in local production. Generally it is difficult to relate chinook catches (especially by troll gear) to local production. For example, Fig. 2 shows that very few or no chinooks spawn in Areas 2E and 5, yet catches reached more than 40,000 pieces in some years for both areas.

Spawning occurs in less than 50 streams and tributaries in Areas 4 and 6. Escapement in recent years has been declining in both areas and is believed due to overfishing by Alaskan and local troll fisheries.

(ii) Coho. No significant trend is observed in coho landings from 1951 to 1979. Catches have been quite variable, ranging from 160,000 to 1 million pieces (Table 1). Few net fisheries are directed at coho so that more than half the landings are caught incidentally in other salmon net fisheries. Trolling is still important in Areas 2E and 5, contributing more than 80% and 65% of the landings in these areas, respectively (Fig. 3).

Coho spawn in a wide variety of streams, creeks, tributaries and headwaters of many rivers. More than 70 streams in Area 2E, 75 streams in Area 4, 35 streams in Area 5 and 50 streams in Area 6 are known to have regular spawning populations. Because of their scattered geographical distribution, accurate escapement estimates are difficult to obtain. Estimates made by fishery officers have shown a sharp decline of spawners since 1963 (especially in Areas 4 and 6) (Fig. 3) but the effect of lower escapement on recruitment is uncertain because of the difficulty of assigning troll-caught fish to their streams (or areas) of origin.

(iii) Chums. Catches have been highly variable due to fluctuations in local abundances. Landings declined sharply in the 1950s due to overfishing. Stringent conservation measures in the early 1960s brought the stocks back to 1951 levels so that catches fluctuated at around 600,000 fish until 1973 when another sharp decline occurred. Catches have remained at low levels up to the present (Fig. 4). Troll catches of this species are negligible. Net catches more or less represent local abundances except in Area 5 where catches may include fish destined to spawn in adjacent areas. It has been recognized recently that chums are the least resilient salmon species in B.C.--optimal exploitation rates are estimated to be as low as 30% for some stocks. Escapements have been depleted severely in recent years by overfishing, especially in Areas 2E and 6.

(iv) Pinks. This is the most abundant species in the study area. Catches from 1951 to 1979 ranged from 600,000 to 8 million pieces. Even-year pinks are significantly more abundant than odd-year pinks, especially in Areas 2E and 6. Landings in even years contribute from 17% to over 50% of the total B.C. pink catch, with Area 6 contributing more than half the catches in our study area. Catches fluctuated at around 2.5 million fish in the 1950s,

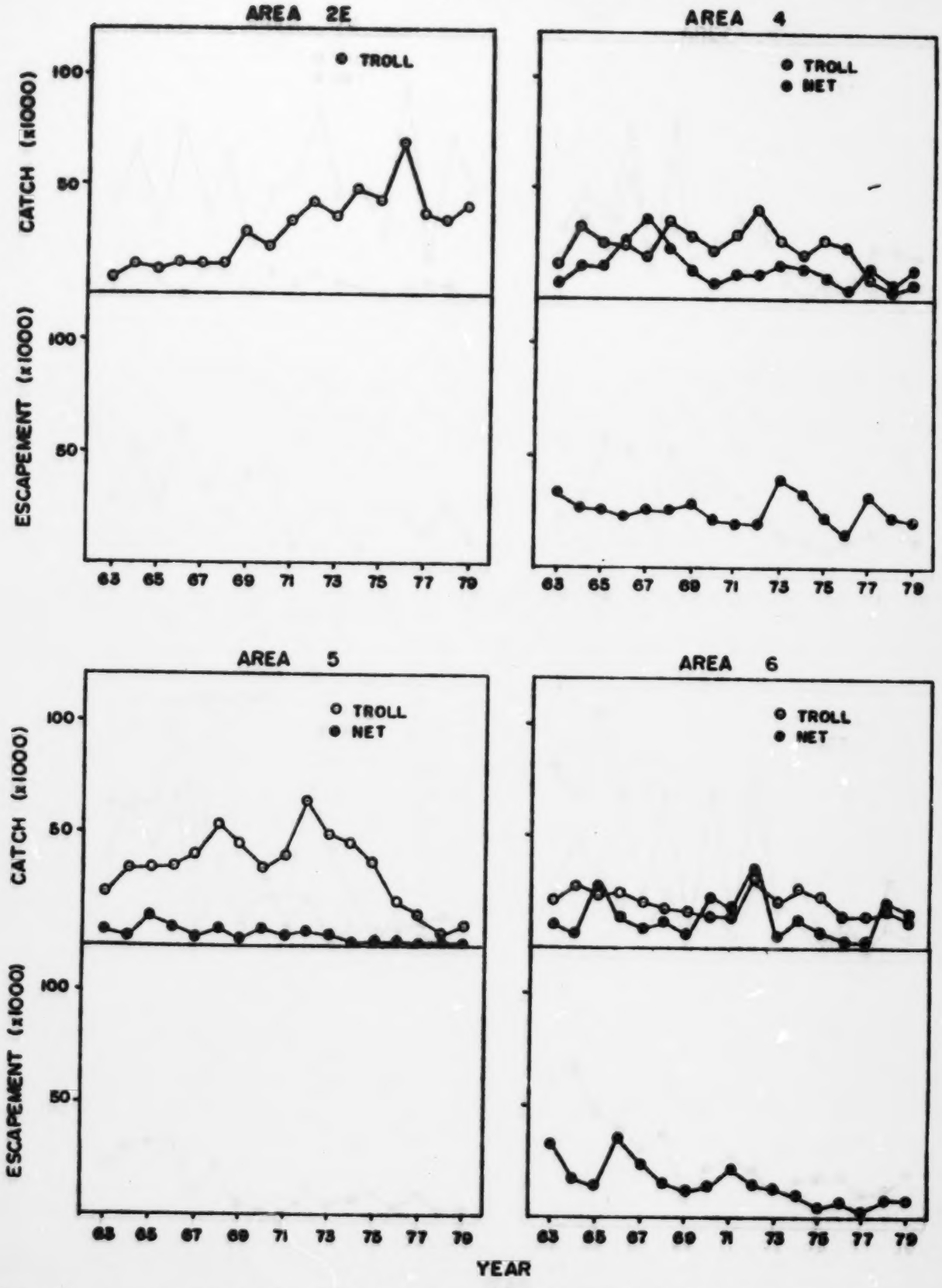

Fig. 2. Annual catches of chinook by troll and net gear, and escapements, in Fishery Areas 2E, 4, 5 and 6, 1963-1979.

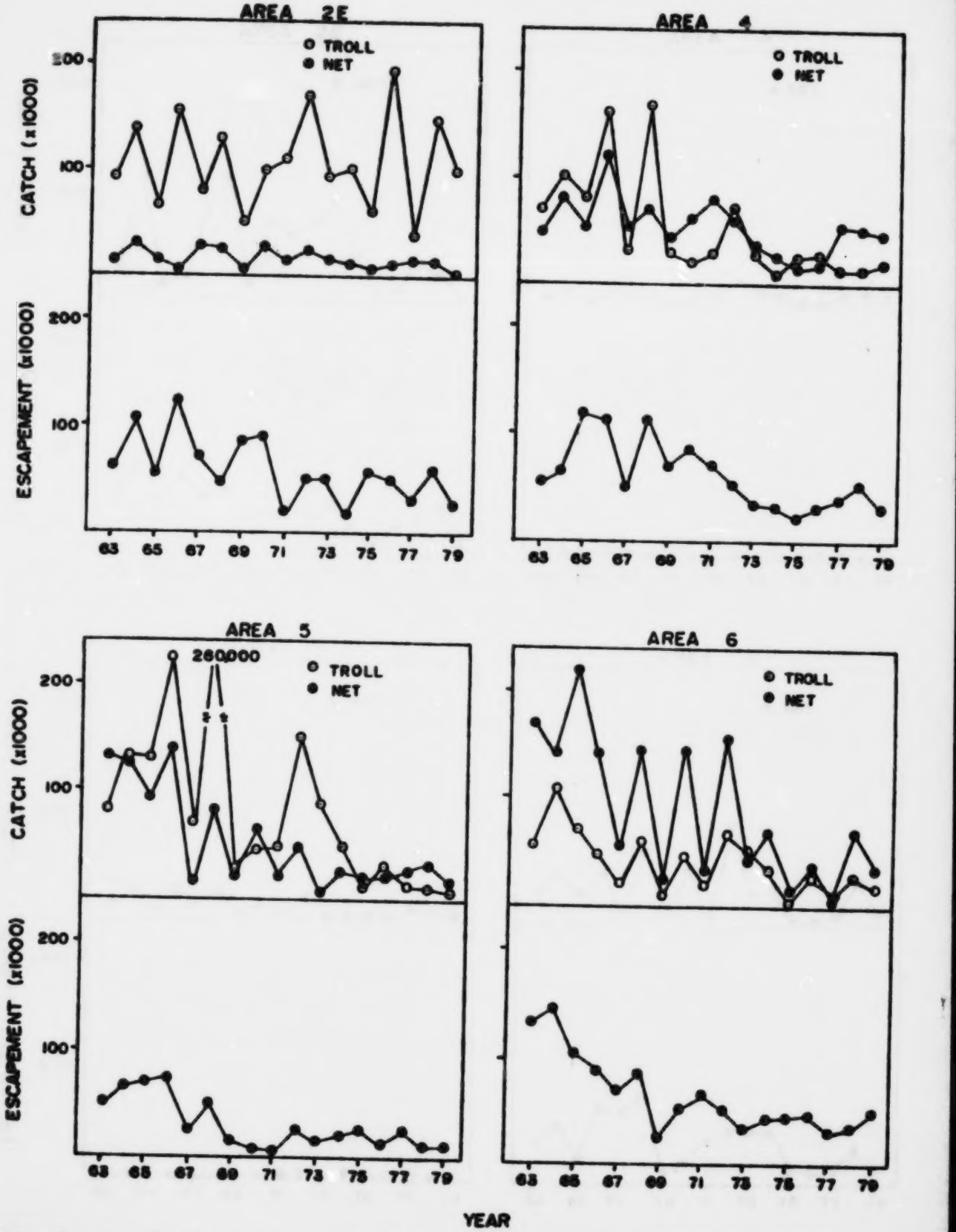

Fig. 3. Annual catches of coho by troll and net gear, and escapements, in Fishery Areas 2E, 4, 5 and 6, 1963-1979.

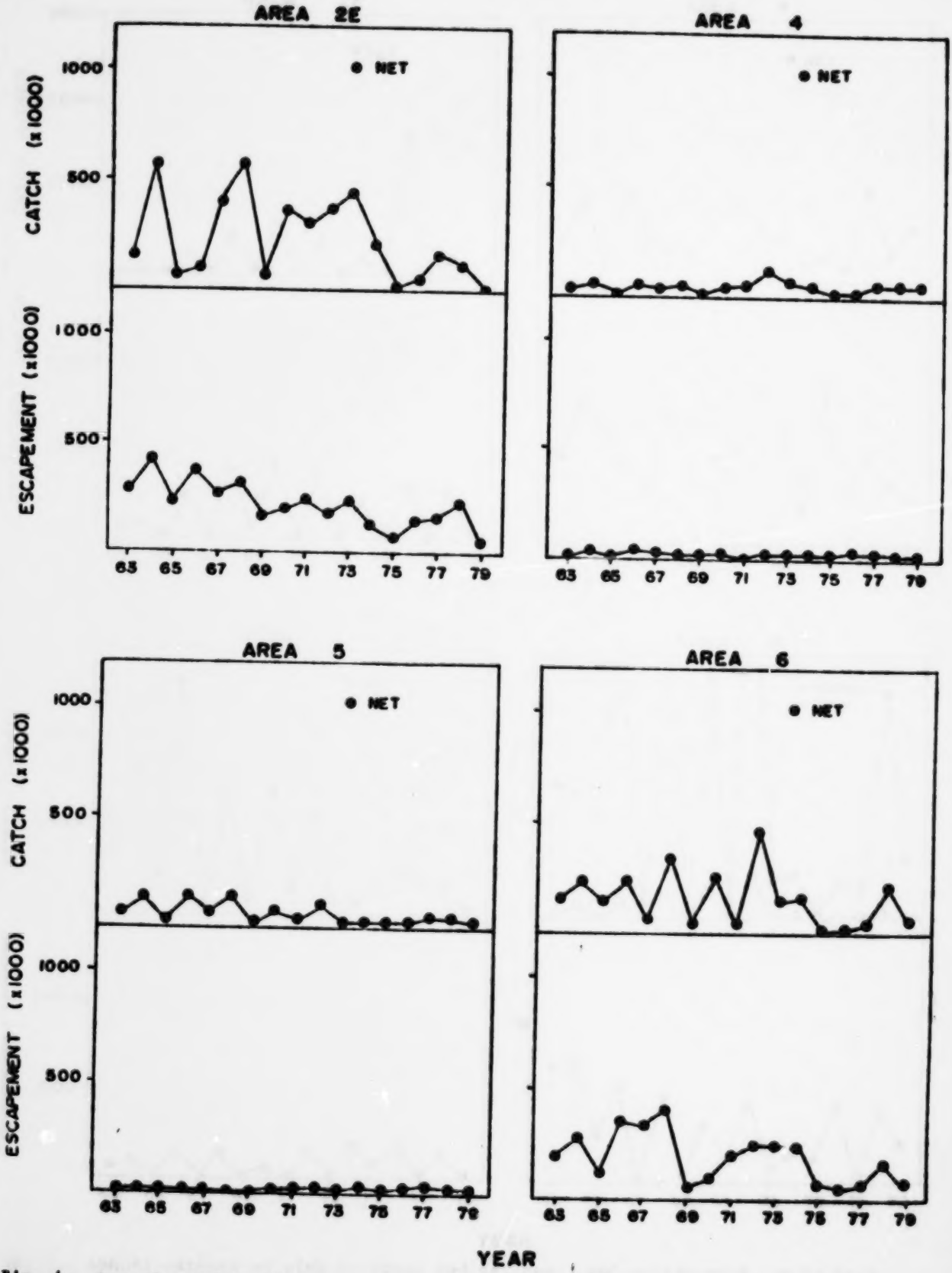

Fig. 4. Annual catches of chum, and escapements, in Fishery Areas 2E, 4, 5 and 6, 1963-1979.

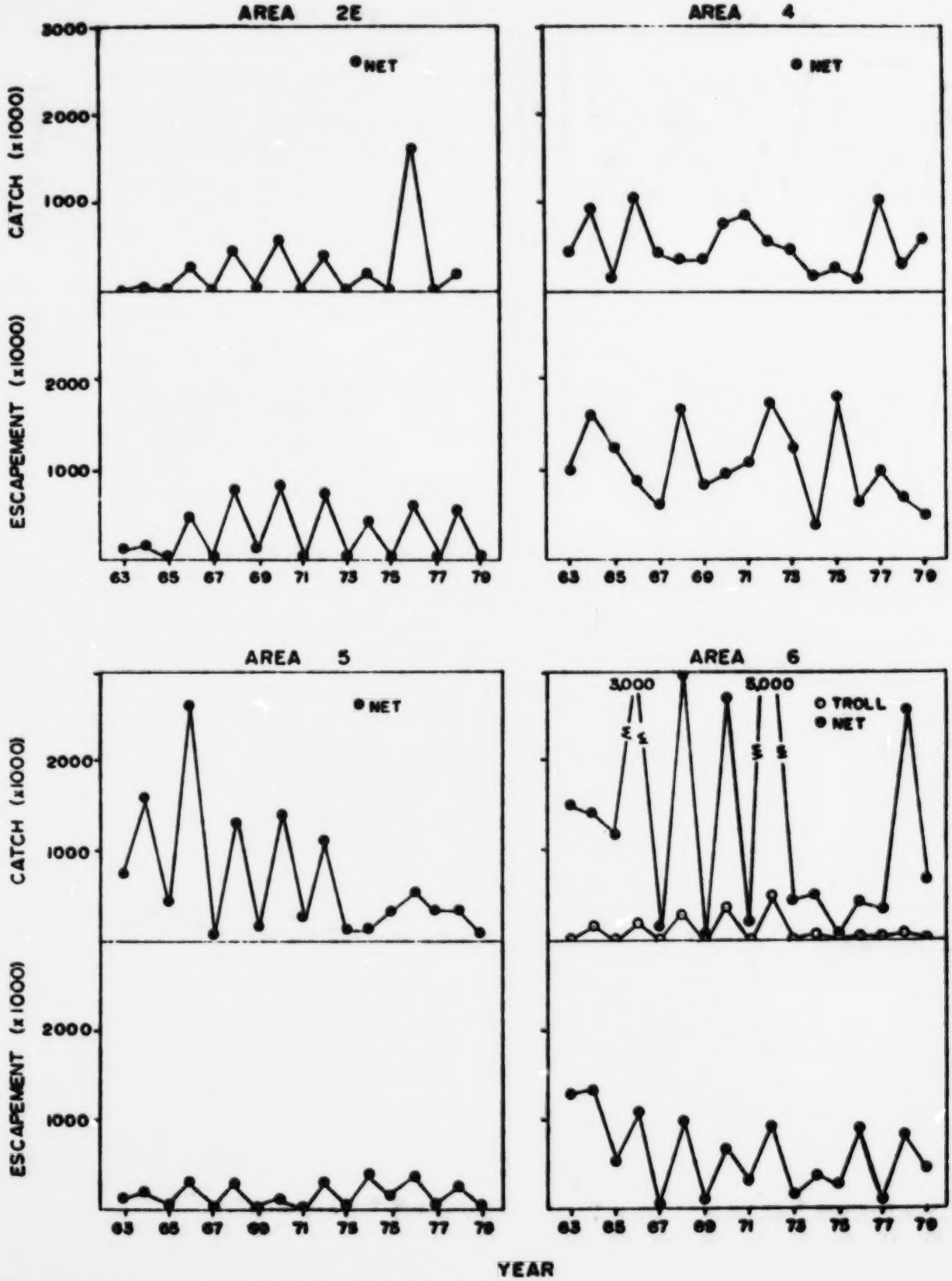

Fig. 5. Annual catches of pink by troll and net gear, and escapements, in Fishery Areas 2E, 4, 5 and 6, 1963-1979.

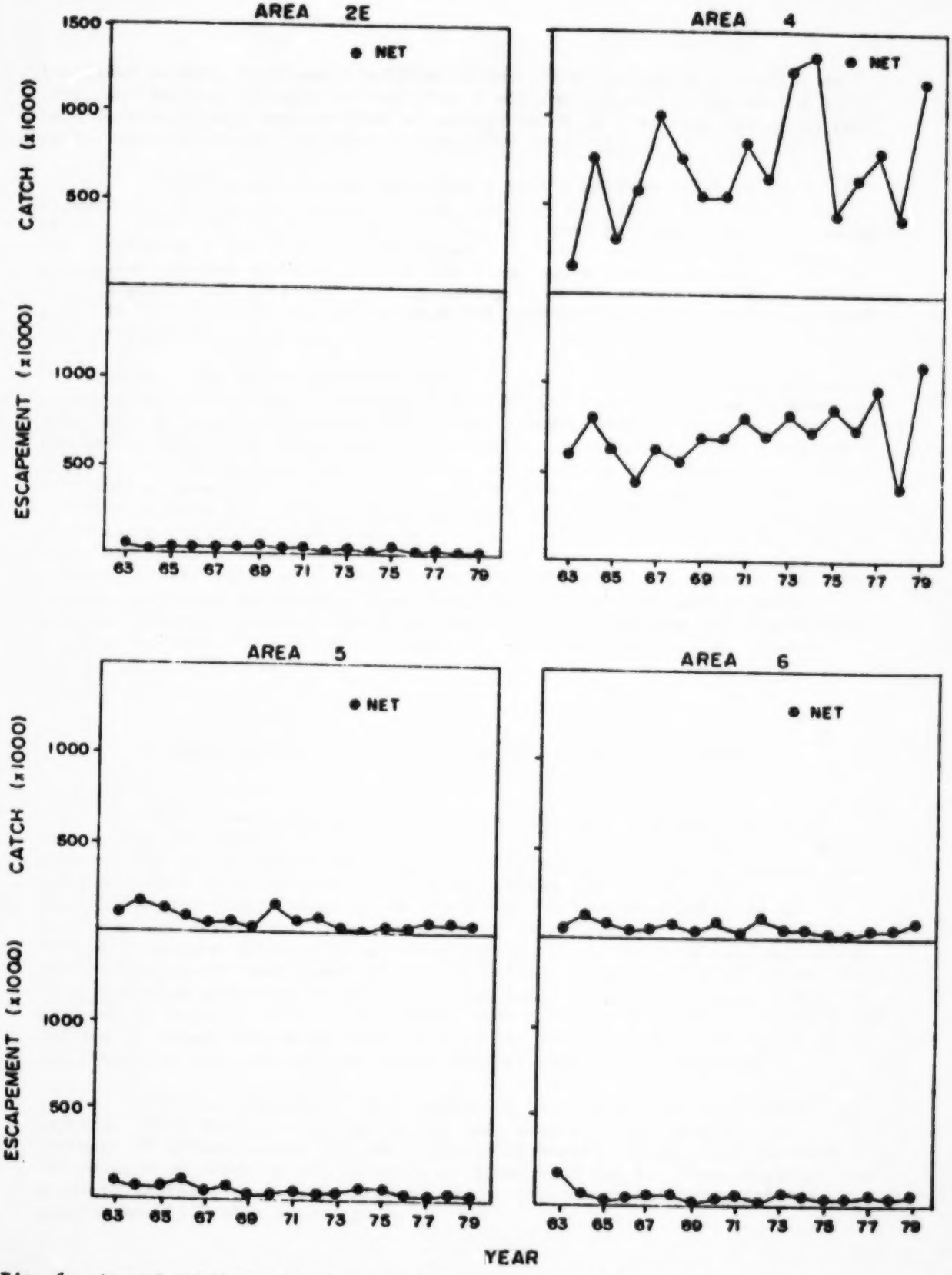

Fig. 6. Annual catches of sockeye, and escapements, in Fishery Areas 2E, 4, 5 and 6, 1963-1979.

increased sharply to around 6 million in the 1960s, peaked at 8 million in 1972, and declined sharply to less than 3 million recently. Odd-year pinks have shown a steady decline from an average catch of 2 million pieces in the early 1960s to around 1 million in the 1970s (Fig. 5).

Trolling may produce more than a half a million pinks in years of exceptional abundances, otherwise troll catches are negligible. Little is known about the migration routes and fleet movement patterns especially among the islands in Areas 5 and 6. Escapements in each area have more or less paralleled catches although some of the large seine fisheries (especially in Areas 5 and 6) may intercept fish migrating to other areas. Spawning takes place in more than 250 coastal streams and tributaries of large river systems around Hecate Strait.

(v) Sockeye. The Skeena River in Area 4 is the predominant sockeye producer in the study area. Catch, escapement and stock-recruitment dynamics have been described in detail by Shepard and Withler (1958), Ricker (1968) and Ricker and Smith (1975). Briefly, catches dropped drastically from over a million fish before 1955 to less than 200,000 in 1955 and the following years. The 1951 Babine River slide blocked most of the spawners from reaching the spawning grounds for 2 years. Recovery began slowly in the early 1960s, and total stock sizes returned close to earlier levels by the late 1970s (Fig. 6). However, the stock composition has changed predominantly to enhanced stocks while wild stocks (especially those in lake systems other than Babine) are being decimated. Traditionally, catches have been taken by gillnet fisheries close to the river mouth and troll catches are negligible. Catches in Areas 5 and 6, which amount to less than 100,000 fish in most years, are mostly from local stocks.

DESTINATIONS OF POST-JUVENILE SALMON IN HECATE STRAIT

Most salmon taggings in and around Hecate Strait have not been directed at determining the origins of salmon in the Strait itself. Some have been carried out to assess the proportions of salmon in Canadian catches which had originated in either U.S. or Canadian waters, as in the Dixon Entrance-Hecate Strait taggings of the 1960s. Others were designed to determine the migration routes and times of passage of local stocks passing through fisheries adjacent to spawning rivers, e.g., the chum taggings among the islands on the east coast of Moresby Island (Dickson 1971, 1975) and those of sockeye and pinks in and around Chatham Sound (Aro and McDonald 1968). Other minor taggings of maturing salmon were made incidentally to catching and tagging of juveniles, as in those done by the Fisheries Research Institute in the 1960s for the International North Pacific Fisheries Commission.

For the purposes of this report we have identified only those taggings which were carried out in the open waters of the Strait, i.e. eastward of Graham Island and the islands off Moresby Island, and westward of the islands adjacent to the mainland of Areas 4, 5 and 6. These taggings are shown in Tables 4 to 9. The list of source references following Table 4 applies to all Tables 4 through 9.

Because fishing and stream recovery efforts vary from area to area and season to season the proportions of recoveries of tagged salmon in different fishing and spawning areas must be used with caution in assessing the abundances of various stocks in the Strait. They may however be used to assess the range of stocks from which the Hecate Strait populations are derived.

(i) Chinooks. Of the 558 chinooks tagged in the Strait, 56 have been recovered. As can be seen from Table 4, the recoveries range from S.E. Alaska through many B.C. fishing areas to as far south as Oregon (probably the Columbia River). The recoveries suggest that in their southward migration chinooks pass either to the eastward of Vancouver Island (Area 12) or westward (Areas 23-27) to the two major southern producers, the Fraser (Areas 28, 29) and Columbia Rivers.

(ii) Coho. Of the 2005 coho tagged in Hecate Strait, 321 have been recovered (Table 5). The recoveries suggest a range of stock origins from S.E. Alaska to southern British Columbia, but most appear to originate from northern and central B.C. coastal rivers (Areas 3-9). Their migration from the Strait to southern B.C. appears to favour the route through Johnstone Strait (Areas 12, 13) rather than the west coast of Vancouver Island (Areas 27, 23), although recoveries are too few to be certain.

(iii) Chums. Recoveries from the few chums tagged in Hecate Strait range from S.E. Alaska to southern Johnstone Strait (Area 13) (Table 6). Recoveries within B.C. have been confined mostly to northern and central B.C. fishing areas (Areas 3-7).

(iv) Even-year pinks. Of the 10,467 even-year pinks tagged in Hecate Strait, 3,021 (29%) have been recovered over an area ranging from S.E. Alaska to southern B.C. (Table 7). A high proportion of the recoveries (774 or 26%) were made in S.E. Alaska, while the bulk of the remainder were made in northern and central B.C. coastal areas (Areas 3-9). The 26 recoveries in Area 12 suggest that some even-year pinks from Johnstone Strait stocks also approach their spawning grounds through Hecate Strait. (Even-year stocks in the Gulf of Georgia are minimal.)

(v) Odd-year pinks. Few (48) odd-year pinks have been tagged in Hecate Strait (Table 8). The recoveries (10) came from Areas 3 and 4 on the B.C. north coast and Areas 11,12, 20 and Washington State to the south. The more southerly recoveries probably represent individuals from the abundant Gulf of Georgia (including Fraser River) and Puget Sound odd-year stocks. The numbers tagged and recovered are insufficient to determine whether or not S.E. Alaska odd-year stocks are present in Hecate Strait.

(vi) Sockeye. Only a few sockeye have been tagged in Hecate Strait (Table 9). Of a total of 10 recoveries, one was recovered in S.E. Alaska, the others in northern and central B.C. fishing Areas (3-9).

Table 4. Summary of tagging and recovery of chinook salmon caught in Hecate Strait. Tagging sites include only those in the open waters of Hecate Strait (the outer portions of Areas 4, 5, 6 and 2E). PS = purse seine, LL = longline, TR = troll, FW = freshwater, M = marine.

	1930		1966[a]		1967[a]		1968[a]		1968[b]		1968[c]		1968[d]		Totals	
References	1		2,3,4,5		2,3,4,5,6		3,4,5,7		3,4,5,7		3,4,5,7		3,4,5,7			
Number tagged	182		12		98		148		9		104		5		558	
Capture gear	TR		PS		TR		TR		TR		TR		TR			
Number recovered	FW	M	FW	M	FW	M	FW	M	FW	M	FW	M	FW	M	FW	M
Alaska		1		1	1							2			1	4
British Columbia																
- Area 3		1														1
- Area 4								1			1	1			1	2
- Area 5								3		1		1				5
- Area 6								2								2
- Area 7								1								1
- Area 9		1										1				2
- Area 12						2		2								4
- Area 23		1														1
- Area 24						2										2
- Area 25														1		1
- Area 26		1						1								2
- Area 27								1								1
- Area 28		1														1
- Area 29		1							1		2				3	1
Unknown												1				1
British Columbia Total	0	6	0	0	0	4	0	11	1	1	3	4	0	1	4	27
Washington	1	1			1							2			2	3
Columbia River	6					1	5				2				13	1
Oregon					1										1	
Total	7	8	0	1	3	5	5	11	1	1	5	8	0	1	21	35

[a]Vicinity of Browning Entrance.

[b]Western Hecate Strait (Area 2E).

[c]Northeastern Hecate Strait (Area 5).

[d]Southeastern Hecate Strait (Area 6).

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Table 5. Summary of tagging and recovery of coho salmon caught in Hecate Strait. Tagging sites include only those in the open waters of Hecate Strait (the outer portions of Areas 4, 5, 6 and 2E). PS = purse seine, LL = longline, TR = troll, FW = freshwater, M = marine.

	1930		1962		1966		1966[a]		1967[a]		1968[a]		1968[b]		1968[c]		1968[d]		Totals	
References	8		9,10		9,10		2,3,4,5		2,3,4,5,6		3,4,5,7		3,4,5,7		3,4,5,7		3,4,5,7			
Number tagged	540		1		5		47		169		521		222		434		66		2005	
Capture gear	TR		LL		LL		PS		TR		TR		TR		TR		TR			
Number recovered	FW	M	FW	M	FW	M	FW	M	FW	M	FW	M	FW	M	FW	M	FW	M	FW	M
Alaska								1				5		5		4		2		17
British Columbia																				
- Area 1												3		1		3				7
- Area 2		1												2		2				5
- Area 3		3								1		11				11				26
- Area 4	2	2					6	3	1	7	1	11		3		6			13	32
- Area 5	1	9						6				24		9		28			1	76
- Area 6		2							1	1	2	25		7		27			3	62
- Area 7		2										10		3		10		1		26
- Area 8	1	7										12	1			11			2	30
- Area 9		3								1		1		2		2				9
- Area 10										2						1				3
- Area 11																1				1
- Area 12																5				5
- Area 13																2				2
- Area 18												1								1
- Area 23		1																		1
- Area 27														1						1
Unknown		2										2		2		2				8
British Columbia Total	4	32	0	0	0	0	6	9	2	12	3	100	1	30	3	111	0	1	19	295
Total	4	32	0	0	0	0	6	10	2	12	3	105	1	35	3	115	0	3	19	312

[a]Vicinity of Browning Entrance.

[b]Western Hecate Strait (Area 2E).

[c]Northeastern Hecate Strait (Area 5).

[d]Southeastern Hecate Strait (Area 6).

Table 6. Summary of tagging and recovery of chum salmon caught in Hecate Strait. Tagging sites include only those in the open waters of Hecate Strait (the outer portions of Areas 4, 5, 6 and 2E). PS = purse seine, LL = longline, TR = troll, FW = freshwater, M = marine.

	1962		1966[a]		1967[b]		1967[a]		1968[a]		1968[c]		1968[d]		Totals	
References	9,10		2,3,4,5		9,10		2,3,4,5,6		3,4,5,7		3,4,5,7		10,11,12,13			
Number tagged	1		?		4		?		6		10		2		23+	
Capture gear	LL		PS		LL		TR		TR		TR		PS			
Number recovered	FW	M	FW	M	FW	M	FW	M	FW	M	FW	M	FW	M	FW	M
Alaska				2						2				1		5
British Columbia																
- Area 1														1		1
- Area 3				2						1		1				4
- Area 4				1		1										2
- Area 5										1						1
- Area 7										1						1
- Area 13										1						1
B.C. Total	0	0	0	3	0	1	0	0	0	4	0	1	0	1	0	10
Total	0	0	0	5	0	1	0	0	0	6	0	1	0	2	0	15

[a] Vicinity of Browning Entrance.

[b] Southeastern Hecate Strait (INPFC Area W3052).

[c] Northeastern Hecate Strait (Area 5).

[d] INPFC Area 3552 only.

Table 7. Summary of tagging and recovery of even-year pink salmon caught in Hecate Strait. Tagging sites include only those in the open waters of Hecate Strait (the outer portions of Areas 4, 5, 6 and 2E). PS = purse seine, LL = longline, TR = troll, FW = freshwater, M = marine.

	1962		1966		1966[a]		1968[a]		1968[b]		1968[c]		1968[d]		1968[e]		Totals	
References	9,10		9,10		2,3,4,5		3,4,5,7		3,4,5,7		3,4,5,7		3,4,5,7		10,11,12,13			
Number tagged	30		128		602		3498		476		4577		1097		59		10,467	
Capture gear	LL		LL		PS		TR		TR		TR		TR		PS			
Number recovered	FW	M	FW	M	FW	M	FW	M	FW	M	FW	M	FW	M	FW	M	FW	M
Alaska		1	1	20		75		584		24		40	1	24		4	2	772
British Columbia																		
- Area 1				1				15		1		6		2		1		26
- Area 2								8				5		2				15
- Area 3		1			3	29		298		9		50		16		7	3	410
- Area 4				3	6	34	31	444		24	8	47	3	21		7	48	580
- Area 5				1		9		218		19		114		50				411
- Area 6				1		3	1	215		18	2	180	1	87			4	504
- Area 7		1				1		17		2		10		11				42
- Area 8		1				3	1	16		6		25	1	52			2	103
- Area 9								3		1		6		9				19
- Area 10												2		2				4
- Area 11												1		2				3
- Area 12				1				6		3	1	9		7			1	26
- Area 20										1		1						2
- Area 29												2						2
Unknown						1		27		2	1	6		5			1	41
B.C. Total	0	3	0	7	9	80	33	1267	0	86	12	464	5	266	0	15	59	2188
Total	0	4	1	27	9	155	33	1851	0	110	12	504	6	290	0	19	61	2960

[a] Vicinity of Browning Entrance.

[b] Western Hecate Strait (Area 2E).

[c] Northeastern Hecate Strait (Area 5).

[d] Southeastern Hecate Strait (Area 6).

[e] INPFC Area 3552.

Table 8. Summary of tagging and recovery of odd-year pink salmon caught in Hecate Strait. Tagging sites include only those in the open waters of Hecate Strait (the outer portions of Areas 4, 5, 6 and 2E). PS = purse seine, LL = longline, TR = troll, FW = freshwater, M = marine.

	1967[a]		1967[b]		Totals	
References	9,10		2,3,4,5,6			
Number tagged	10		38		48	
Capture gear	LL		TR			
Number recovered	FW	M	FW	M	FW	M
British Columbia						
- Area 3				1		1
- Area 4				4		4
- Area 11		1				1
- Area 12		1		1		2
- Area 20		1				1
British Columbia Total	0	3	0	6	0	9
Washington		1				1
Total	0	4	0	6	0	10

[a] INPFC Area W3052.

[b] Vicinity of Browning Entrance.

Table 9. Summary of tagging and recovery of sockeye salmon caught in Hecate Strait. Tagging sites include only those in the open waters of Hecate Strait (the outer portions of Areas 4, 5, 6 and 2E). PS = purse seine, LL = longline, TR = troll, FW = freshwater, M = marine.

	1966[a]		1966[b]		1967[c]		1967[b]		1968[b]		1968[d]		1968[e]		Totals	
References	9,10		2,3,4,5		9,10		2,3,4,5		3,4,5,7		3,4,5,7		10,11,12,13			
Number tagged	1		?		4		?		4		8		1		18+	
Capture gear	LL		PS		LL		TR		TR		TR		PS			
Number recovered	FW	M	FW	M	FW	M	FW	M	FW	M	FW	M	FW	M	FW	M
Alaska										1						1
British Columbia																
- Area 3				1												1
- Area 4				3		1										4
- Area 5				2												2
- Area 6				1												1
- Area 9				1												1
B.C. Total	0	0	0	8	0	1	0	0	0	0	0	0	0	0	0	9
Total	0	0	0	8	0	1	0	0	0	1	0	0	0	0	0	10

[a] INPFC Areas W3552 and W3052.

[b] Vicinity of Browning Entrance.

[c] INPFC Area W3052.

[d] Northeastern Hecate Strait (Area 5).

[e] INPFC Area W3552.

ORIGINS OF POST-JUVENILE COHO AND CHINOOK IN HECATE STRAIT FROM CODED WIRE TAGGING

The coastwide Chinook and Coho Sampling and Mark Recovery Program was initiated in 1973 to provide information required for chinook and coho management and enhancement (Argue 1976). Juveniles marked with coded wire tags have been released from hatcheries and some wild stocks in British Columbia and the United States. When marked fish are recovered in the catch their freshwater origin can be determined.

For this report, we have assembled information on the coastal origins and numbers of coded wire tagged coho and chinooks recovered in the study area (Statistical Areas 2E, 4, 5, 6). The reader is cautioned not to interpret numbers of tags recovered as reflecting proportions of stocks contributing to the fisheries (To estimate fishery contribution other information such as marked/unmarked ratio, tag loss, sampling intensity, etc. must be taken into account). However these data provide some qualitative information about the diversity of stocks that may be present in and around Hecate Strait during the fishing season.

(i) Chinooks. A total of 1205 hatchery and 29 wild CWT chinooks were recovered in 1977, 78, 80 and 81 (Table 10) (The data for 1979 are as yet unavailable). A significant increase in tags recovered in 1980 and 1981 probably reflects the increase in hatchery output of tagged fish in the United States and B.C. The origins of the CWT chinooks ranged from S.E. Alaska, throughout B.C. and Washington, to as far south as the Oregon coast. Because relatively few wild chinook juveniles are tagged, the range of origins of wild chinooks present in Hecate Strait may be underrepresented in comparison to that for hatchery stocks.

(ii) Coho. A total of 81 hatchery and 12 wild CWT coho were recovered in 1977, 78, 80, 81 (Table 11). The origins of these fish ranged from S.E. Alaska to as far south as the Oregon coast. The recoveries of wild fish are too few to provide useful information on the full range of wild coho stocks present in the Hecate Strait area.

JUVENILES

There have been no studies directed specifically at assessing the importance of Hecate Strait as a feeding area or migration route for juvenile salmon. Some information can be gleaned from observations made incidentally to other projects regarding time of entry into the Strait, period of residence, feeding, behaviour and growth.

The likely times and sizes at entry by sockeye, pink and chum juveniles can be inferred from observation of the departure times of seaward migrants from streams and coastal areas bordering Hecate Strait, Dixon Entrance and Queen Charlotte Sound (Manzer 1956, Manzer and Shepard 1962, Parker 1968, 1971). Information on growth, food habits and seasonal residence

CHINOOK

	1977		1978		1980		1981	
	HATCHERY	WILD	HATCHERY	WILD	HATCHERY	WILD	HATCHERY	WILD
North Coast	-	-	-	-	2	-	9	5
Central Coast	-	-	-	-	37	4	23	-
E. Van. Isl.	9	-	11	-	122	-	87	4
W. Van. Isl.	8	-	10	-	64	3	46	2
Fraser River	-	-	1	-	-	-	-	2
TOTAL CANADA	17	-	22	-	225	7	165	13
Alaska	-	-	-	-	-	-	1	-
Wash. Coast	29	-	3	-	12	-	21	-
Puget Sound	1	-	-	-	59	-	15	-
Columbia River	56	-	23	-	262	4	143	5
Oregon Coast	78	-	8	-	34	-	31	-
TOTAL U.S.	164	-	34	-	367	4	211	5
GRAND TOTAL	181	-	56	-	592	11	376	18

Table 10. Origins and numbers of coded wire tagged chinooks recovered in the Hecate Strait study area, 1977, 1978, 1980 and 1981.

COHO

	1977		1978		1980		1981	
	HATCHERY	WILD	HATCHERY	WILD	HATCHERY	WILD	HATCHERY	WILD
North Coast	-	-	-	1	-	-	-	-
Central Coast	-	-	-	2	-	4	-	-
E. Van. Isl.	-	-	4	2	26	-	13	-
W. Van. Isl.	-	-	3	-	2	-	-	-
Fraser River	-	-	-	1	-	1	-	-
TOTAL CANADA	-	-	7	6	28	5	13	-
Alaska	-	-	-	-	10	-	7	-
Wash. Coast	-	-	-	-	1	-	3	-
Puget Sound	-	-	-	-	2	-	1	-
Columbia River	-	-	-	-	-	-	-	-
Oregon coast	-	-	-	-	2	1	7	-
TOTAL U.S.	-	-	-	-	15	1	18	-
GRAND TOTAL	-	-	7	6	43	6	31	-

Table 11. Origins and numbers of coded wire tagged coho recovered in the Hecate Strait study area, 1977, 1978, 1980 and 1981.

can be pieced together from observations by LeBrasseur and Parker (1964), Taylor (1970), Taylor et al. (1970a, b, c, d), Hart and Dell (1978) and the Fisheries Research Institute (1969). Other information, as yet unpublished, may be available from the Fisheries Research Institute (FRI) of the University of Washington.

We have been unable to find any information, except by inference from coastal studies, regarding the importance question of the stock origins of young salmon in the Strait.

In the following sections we will attempt to construct, by species, as much as possible of the life history of juvenile salmon in Hecate Strait.

(i) Chinooks. We have been unable to find any reference from which to infer the times at which chinook juveniles enter the Strait during their first year of sea life. It is possible that the time of entry is quite variable because the two juvenile life history types ("stream" and "ocean") are quite different in size at first entering salt water. Stream-type chinook juveniles spend one year in fresh water before going to sea and hence are larger, while the ocean-type spend only a few months in fresh water after emergence and are smaller.

The earliest recorded seasonal observation of abundant young chinook in the Strait is July 20 (in 1968) (FRI 1969). At that time 13 juveniles caught by purse seine,tagged and released off Browning Entrance averaged 21.5 cm. In 1969, in a herring trawl survey during the period September 15-October 1, several juvenile chinooks were caught in southern Hecate Strait (Taylor et al. 1970a). Seven ocean-type juveniles averaged 27.6 cm and 11 stream-type averaged 30.0 cm. Stomach contents consisted mainly of euphausiids and sandlance. (Ten immature chinooks that had spent one or more years at sea also were taken during this survey.) Similar trawl surveys carried out later in the winter of 1969-70 (Nov. 24-Dec. 10, Jan. 26-Feb. 10) produced no juvenile chinooks; an early spring survey from April 7-23 produced 5 juveniles which might have entered the Strait in the previous summer. They averaged 41.7 cm and were feeding on euphausiids, herring and sandlance (Taylor et al. 1970b, c, d). The lack of young chinooks in winter catches doesn't mean that they were absent during the winter - winter trawling usually was directed at deep, schooled targets identified by echo sounder.

(ii) Coho. The time of entry of juvenile coho into Hecate Strait in their first year of sea life is unknown. Parker (1968) found that coho accompanied and fed on pink fry as they migrated seaward along Burke Channel from the Bella Coola River. The pink fry, and presumably the coho smolts,arrived at the confluence of Burke and Fisher channels and Fitzhugh Sound (within the outer islands fringing Queen Charlotte Sound) about June 1. Hence it seems likely that many of the coho would have proceeded from among the islands into the Sound during June and early July. It is likely that a comparable migration schedule would apply to young coho entering Hecate Strait.

The earliest seasonal catches of abundant juvenile coho were made on July 20 and 21 (in 1968). Sixty-five coho in their first summer at sea were taken by purse seine, tagged, and released off Browning Entrance. Their average length was 22.9 cm. A purse seine set on August 8 in the same year

produced 3 coho suitable for tagging whose average length was 30.7 cm (FRI 1969). The average length of 6 coho taken by herring trawl during September 15-October 1 in 1969 was 27.8 cm (Taylor et al. 1970a). No juvenile coho were caught in herring trawls during the winter and early spring of 1969-70, in hauls that were usually made in deep water and not directed at salmon.

(iii) Chums. Parker (1971) reports that Bella Coola chum fry entered coastal waters in company with pink fry from March to May with a peak in late April. Their length at that time was about 3.8 cm, which must approximate the size of young chums entering Hecate Strait coastal waters directly, as would be the case on the east coast of the Queen Charlotte Islands.

We have found no record of their sizes during the first 2 months at sea. Chums were present in Chatham Sound in 1955 from early June until the first half of July, by which time they were abundant in Beaver Pass. By early August, no chums were caught on the beaches of Chatham Sound and only a few were taken in Ogden Channel. By the end of August they were taken only in Caamano Pass, in eastern Dixon Entrance (Manzer 1956, Manzer and Shepard 1962). From the distribution of catches in and around Chatham Sound it appears that chums were leaving the Sound to enter Dixon Entrance and Hecate Strait from mid-June until early August. (In a parallel survey in Queen Charlotte Strait in the same year, the time of departure into Queen Charlotte Sound appeared to coincide roughly with that at Chatham Sound [Manzer 1956]).

In the Hecate Strait herring trawl survey from July 19-30, 1969 no juvenile chums were caught, although 6 young pinks were caught in the same period (Taylor 1970). FRI reports tagging 6 chum juveniles caught by purse seine off Browning Entrance on July 20 and 21, 1968. Their average length was 18.0 cm. A purse seine set on August 8, 1968, produced 4 chums whose average length at tagging was 20.3 cm (FRI 1969). During the herring trawl survey from September 15-October 1, 1969, fifty chum juveniles were taken in 10 hauls (28 contained none). They averaged 21.6 cm and had been feeding mainly on euphausiids. Catches were greatest in southwestern and northeastern Hecate Strait. All were taken in surface hauls in the early morning or late evening (Taylor et al. 1970a).

In a series of 10 experimental trawl hauls in Hecate Strait, November 3-14, 1963 LeBrasseur and Barner (1964) report catching 142 age 0 chum salmon averaging 21.0 cm and weighing 85 g. The 2 largest catches were made in northern Hecate Strait in the vicinity of 53°54'N , 130°53'W, west of Porcher Island. The stomach contents were mostly unidentifiable except for some squid remains. Most stomachs were empty in morning catches. Comparing catches from various depths and at different times suggested that the juveniles tended to be near surface during the night, sounding before dawn and rising after daybreak. During the day they appeared to remain at mid-depths (below pinks), rising to the surface at dusk.

Two chums were caught during the herring trawl survey of November 24-December 10, 1969, in southeastern Hecate Strait. No chums were taken in the trawl surveys of January 26-February 10 and April 7-23, 1970 (Taylor et al. 1970b, c, d). These surveys were directed mainly at deep targets.

(iv) Pinks. In a 1955 survey of juvenile salmon in Chatham Sound, pink fry were present on all beaches sampled during the first 2 weeks of June. Later in June fewer were caught along the outer ring of islands but some were taken over deep water outside Prescott Island. During July the numbers around the islands decreased further except in Beaver pass. By mid-August young pinks were no longer available along the beaches; some were caught in Browning Entrance and Hecate Strait, one-half to 4 m from land. In September some were caught in Dixon Entrance 6-12 m southwest of Zayas Island. The pattern of catches in and around Chatham Sound suggests that pink juveniles were entering Dixon Entrance and Hecate Strait from late June until mid-August (Manzer 1956, Manzer and Shepard 1962). (In a similar survey in Queen Charlotte Strait, it appeared that pinks had left the Strait for Queen Charlotte Sound by mid-August.) During the period of residence in and around Chatham Sound, the juveniles fed heavily on copepods and Oikopleura (Manzer 1969). We have no record of the size of juveniles at the time of entry into Hecate Strait, but must assume that it would be variable because the period of leaving the coastal islands appears to be quite protracted. (Parker [1968] reports that Bella Coola pink fry entering the sea averaged 3.5 cm.)

In 1968 two pinks were tagged from a purse seine set off Browning Entrance on July 21. They averaged 18.4 cm (FRI 1969). Six juveniles caught in the 1969 herring trawl survey in south central Hecate Strait on July 27 averaged 13.8 cm (Taylor 1970). Fifty-two juveniles tagged from a purse seine set off Browning Entrance on August 27, 1968 averaged 18.0 cm (FRI 1969). During the herring trawl survey from September 15-October 1, 1969, 131 pinks were caught in 13 hauls out of a total of 37 made in the Strait. Their average length was 20.9 cm. Areas of concentration during this cruise were in southwestern Hecate Strait, centred on 52°45'N , 131°00'W, in west central Hecate Strait off Banks Island, and in north central Hecate Strait off Browning Entrance. Almost all hauls containing pinks were surface tows made at dawn or dusk (Taylor et al. 1970a).

In 20 sets of an experimental trawl, made mostly in northeastern Hecate Strait, LeBrasseur and Barner report catching 241 pink juveniles from November 3-14, 1963. They measured 20.0 cm and weighed 67.8 g on average. They were caught most often at the surface both day and night. Stomach contents were greatest during the day, and all were full. One-third of the stomachs of those caught at night were empty. Food consisted of euphausiids, amphipods and copepods (One catch on the Horseshoe Grounds produced stomachs containing Limacina).

No pinks were caught in herring trawl surveys during the winter and early spring of 1969-70 (Taylor et al. 1970b, c, d).

(v) Sockeye. In the 1955 survey of juvenile salmon in Chatham Sound, sockeye were present in the Skeena River mouth and on the beaches in the first 2 weeks of June. Thereafter catches declined and none was taken after mid-July. Apparently the sockeye entered Dixon Entrance and Hecate Strait mainly during June and July (Manzer 1956, Manzer and Shepard 1962). (In the Queen Charlotte Strait survey of the same year, some sockeye were found over deep water as late as early September.) During their stay in Chatham Sound the sockeye had fed on copepods, larvacea and some small fish.

Six sockeye tagged from seine sets off Browning Entrance on July 20 and 21, 1968 averaged 18.0 cm. In a later set (August 8) in the same area, 42 tagged juveniles averaged 19.9 cm (FRI 1969). The 1969 Hecate Strait herring trawl survey from September 15-October 1 produced 10 juveniles whose average length was 19.6 cm. They had been feeding mostly on euphausiids (Taylor et al. 1970a). Six sockeye were caught in trawl tows between November 4 and 15, 1963 in northern Hecate Strait. Their sizes and stomach contents were not recorded (LeBrasseur and Barner 1964). Herring trawl surveys during the winter and early spring of 1969-70 produced no juvenile sockeye (Taylor et al. 1970b, c, d).

SUMMARY AND RECOMMENDATIONS

Our review of observations of salmon in Hecate Strait reveals that our knowledge is as yet insufficient to assess the Strait's importance to B.C. salmon production. What information we have, aside from commercial catches, is derived largely from projects designed for other purposes, and there has been no systematic effort to understand the salmons' presence there in ecological terms.

Fishing areas adjacent to and including Hecate Strait (Areas 2E, 4, 5 and 6) contribute significant proportions of B.C.'s commercial salmon landings. Our review shows that on average 35% of B.C.'s even-year pink catch, 20% of the odd-year pink catch, 20% of the chum catch, 17% of the sockeye catch, 13% of the coho catch and 11% of the chinook catch are taken from these areas. However, the bulk of sockeye, pink and chum catches come from net fishing in the shoreward fringes of the fishing areas, from either the mainland edges of Areas 4, 5 and 6, or among the islands bordering the eastern side of Moresby Island in Area 2E. These net fisheries are directed largely at local salmon stocks approaching the large number of spawning streams along the central and northern B.C. coast and S.E. Alaska.

On the open waters of Hecate Strait itself, trolling for chinooks and coho is the main salmon fishery. We estimate that trolling on the Strait accounts for about 70% of the chinook landings of Areas 2E, 4, 5 and 6, and that it accounts for over half the coho caught in these areas. Nevertheless, the numbers of coho and chinook caught in the Strait amount to less than 5% of the combined total B.C. landings of these species.

The destinations of the post-juvenile and maturing salmon present in the Strait are widespread. Recoveries of chinooks tagged in the Strait have ranged from S.E. Alaska to the Columbia River in Oregon. Many of the tagged chinooks were caught in troll fisheries off the west coast of Vancouver Island, apparently en route to the Columbia and Fraser rivers. The distribution of coho recoveries ranges from S.E. Alaska to southern B.C., but the bulk of coho recaptured after tagging has been taken in northern and central B.C. coastal Areas 3-9, suggesting a more restricted range of destinations of these maturing fish. The few chum salmon tagged in the Strait

and recovered later suggest that their origins were largely central and northern B.C., and S.E. Alaskan, streams. The numerous recoveries of tagged even-year pinks range from S.E. Alaska through northern and central B.C. as far south as Johnstone Strait. The few recoveries of tagged odd-year pinks suggest that their origins included northern B.C. stocks and the abundant odd-year Strait of Georgia and Puget Sound stocks. The few recoveries of tagged sockeye suggest that they originated mostly from northern and central B.C. coastal stocks.

Recoveries in the Strait of chinook and coho salmon which had been tagged as juveniles with coded wire tags suggest a range of origins similar to those derived from tagging maturing fish. However, because many hatchery juveniles are tagged, and few wild ones are, the CWT recoveries overrepresent the hatchery origins of salmon caught in the Strait as opposed to those of wild stocks present.

On the basis of actual catches, juveniles of all 5 species are present in the open waters of Hecate Strait from at least mid-July until October, and in the case of chums, pinks and sockeye, until November. The observations show that the juveniles are feeding and growing in the Strait during this period. We have no measures of their abundance in the Strait or their relationship to the annual summer and fall northwesterly migration of juvenile salmon along the coast from Washington to the Aleutian Chain. (It has been suggested that the juveniles in Hecate Strait may represent a portion of that moving band of young salmon.) We may safely infer that at least some of the juveniles present arise from spawning stocks in the adjacent central and northern areas; the degree to which representatives from more distant stocks are present is unknown.

With respect to our criteria for priorizing studies of Hecate Strait fishes, it is apparent that the Strait is an important pathway for incoming, maturing salmon representing stocks of significant economic value. These stocks are based largely in coastal areas more or less remote from the Strait itself and, except perhaps for chinooks and coho, are not fished heavily in the Strait. The abundances of the stocks represented in the Strait do vary from year to year and over long periods, but these fluctuations cannot reasonably be ascribed to fishing in the Strait. Since salmon have rather short life spans (2-5 yr), it should be possible to assess the effects of large perturbations in only a short time, but the effects would have to be measured over wide areas outside the Strait, i.e. in other fishing areas and on appropriate spawning grounds.

Year-class variability in stock abundance is much more likely to be associated with conditions prevailing at early life stages. The role of the Strait in these respects in virtually unknown. (It is also at this stage that a major perturbation such as an oil well blowout would have most effect.) To begin to understand the role of the Strait at this early stage, it will be necessary to determine the times when juveniles are present, where they are and what their feeding and survival requirements are while there. Present information does little more than demonstrate that juveniles are present during the summer and fall, but cannot be used to determine their origins, abundances or the relative importance of the Strait as a rearing area.

To assess its role, it will be necessary initially to sample juvenile salmon systematically and quantitatively over the whole Strait. Sampling surveys should begin in late June and extend through October on a monthly basis. (During the winter and early spring the surveys need only be repeated once every 2-3 mo.) Fishing would be carried out either by fine-meshed seine or trawl or both, from vessels suitable for continuous operation in open waters. Since it will be important ultimately to determine the origins of juveniles present, it will be necessary to develop tagging techniques with sea-going capability, which will permit identification of tagged juveniles later as they pass through fisheries as maturing adults on their return to spawning grounds.

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